ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

esa

ReadMe-first Technical Note (RM-TN)

Document Version

Version	Date	Description	Author
1.1	19/10/2018	Revision after comments from ESA	Robert Ricker (AWI)
1.0	15/06/2018	Draft of the ReadMe-first Technical Note	Robert Ricker (AWI)

Applicable Documents

Abbreviation	Name	Description
ATBD	AWI_ESA_CS2SMOS_ATBD_v1.0	Algorithm Theoretical Basis Document
PDD	AWI_ESA_CS2SMOS_PDD_v1.1	Product Description Document

Read-me-first note for the release of theCryoSat-2/SMOS Merged Sea Ice Thickness (CS2SMOS)	
Product version	v200, v201
Release date by ESA	*add date*
Author(s)	Robert Ricker
Further information	A detailed description of the processing algorithm can be found in the Algorithm Theoretical Basis Document (ATBD): *add link* Information about the data product ca be found in the Product description document (PDD): *add link* Information on how to access the CS2SMOS ice thickness data can be found here.
How to cite the data	1. Please cite: Ricker, R., Hendricks, S., Kaleschke, L., Tian-Kunze, X., King, J., and Haas, C.: A weekly Arctic sea-ice thickness data record from merged CryoSat-2 and SMOS satellite data, The Cryosphere, 11, 1607-1623, https://doi.org/10.5194/tc-11-1607-2017, 2017. 2. Include the following phrase into the acknowledgment: "The production of the merged CryoSat-SMOS sea ice thickness data was funded by the ESA project SMOS & CryoSat-2 Sea Ice Data Product Processing and Dissemination Service, and data from DATE to DATE were obtained from AWI."
Contact for helpline	For all issues related to data access, please contact ESA's HelpDesk at eohelp@esa.int
Comments to CryoSat-2/SMOS merged product	For questions and feedback, please contact: Robert.Ricker@awi.de Stefan.Hendricks@awi.de

1. Introduction

The read-me-first note provides information about improvements with regard to the previous releases, data caveats, and instruction about how to use auxiliary data and uncertainties contained in the product.

The product version v200 is available from November 2010 to April 2016. The current product version v201 is available since October 2016 and is now continuously generated within the framework of the ESA project **SMOS & CryoSat-2 Sea Ice Data Product Processing and Dissemination Service**. The product is only available for the Northern Hemisphere from October to April.

2. Main Improvements in the current Data Set

The current version is v201. It is available since October 2016. Version v200 is available since November 2010 and, compared to version v201, only differs by using an older product version of the OSI SAF ice concentration data set (OSI-401) for the processing, affecting the mean ice coverage in coastal areas. The sea-ice thickness, however, is not affected. The main changes in v200 and v201 compared to version v1.4 are:

- Introduction of an operational mode that allows processing of the weekly merged product with a timeliness of 2 days. This means that the weekly CS2SMOS product (covering Monday-Sunday) is generated Tuesday night the week after (CET).

- For the operational mode (o), we use a reconstructed background field - utilizing only sea ice thickness data acquired two weeks prior to the target week by applying a phase shift correction to accommodate for the advancing ice growth. For the reprocessing (r) campaigns we will then use the full background field as described in Ricker et al. (2017).

- We adapted the CS2SMOS processing to changes in the CryoSat-2 sea ice thickness product version v2.1, which is now used for the data merging with SMOS sea ice thickness retrievals v3.1.

- Changes in the file naming due to introduction of the near-real-time processing and to be in line with the CryoSat-2 sea ice thickness product version v2.1 file naming. See therefore the Product Description Document (PDD).

3. Product Performance

CS2SMOS, CryoSat-2 and SMOS Ice Thickness Uncertainties

The uncertainties of the CryoSat-2 and SMOS sea ice thickness observations are crucial for the data merging and the interpolation. Figure 1 shows the relative uncertainties of CryoSat-2 and SMOS for November 2013 and April 2014. While the SMOS relative uncertainties are lowest for very thin ice, CS2 relative thickness uncertainties are smaller over thick ice and rise asymptotic towards thickness values < 1 m, which is due to the different methodical approach. The merged product (CS2SMOS) takes advantage of the complementary uncertainties. CS2SMOS merged ice thickness shows a significant reduction in the relative uncertainty with regard to the thickness uncertainties of the thin ice in the CryoSat-2 product, and the thick ice in the SMOS product.

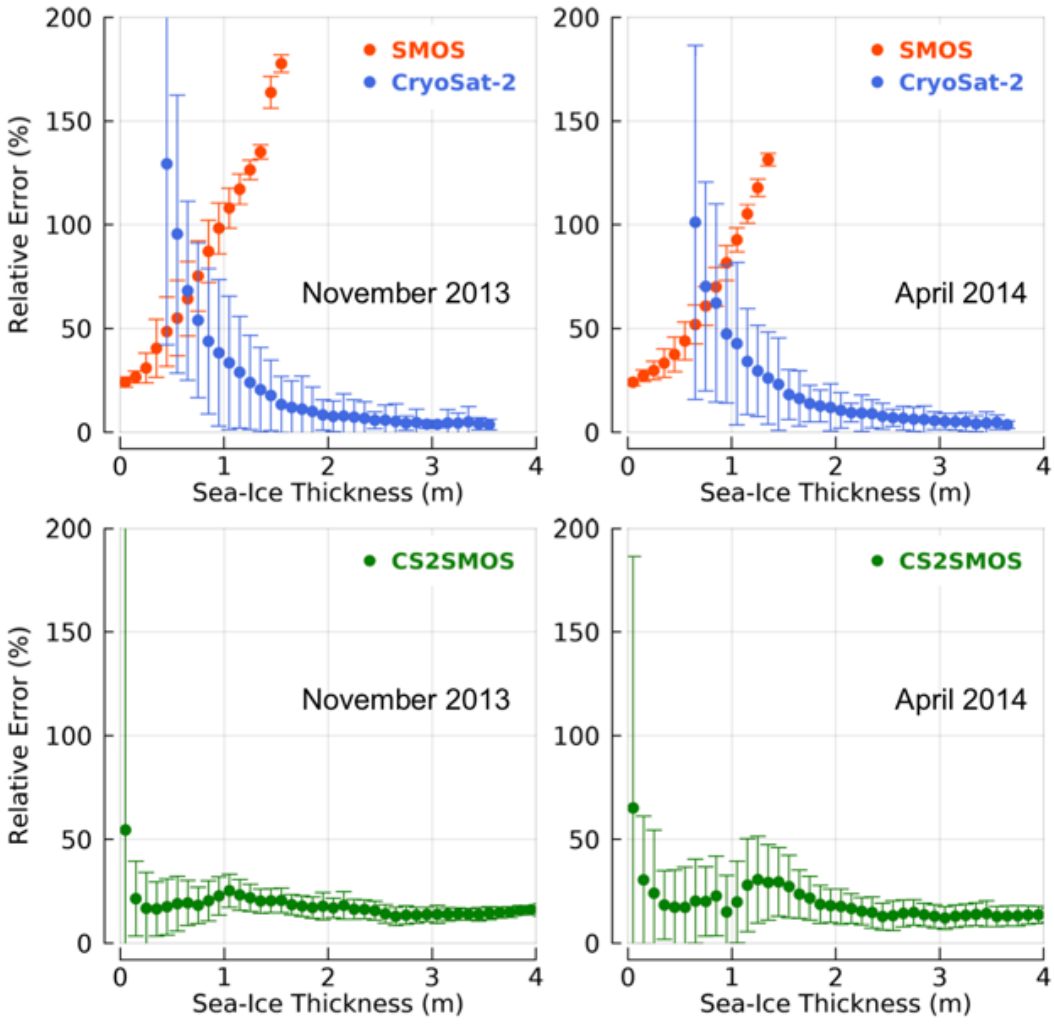

Figure 1: Binned Relative uncertainties for November 2013 and April 2014. Error bars indicate the standard deviation of relative uncertainties within the 10 cm bin width.

Differences between CS2SMOS v200-operational and v200-reprocessd

Since the background field in the operational mode only includes the two weeks prior the target week, we expect differences when comparing the operationally processed data with the reprocessed data, which use the full background field, including two weeks prior and two weeks after the target week (see ATBD). Figure 2 shows the differences for the week March 26, 2018 – April 01, 2018. Differences are in the same order for other weeks.

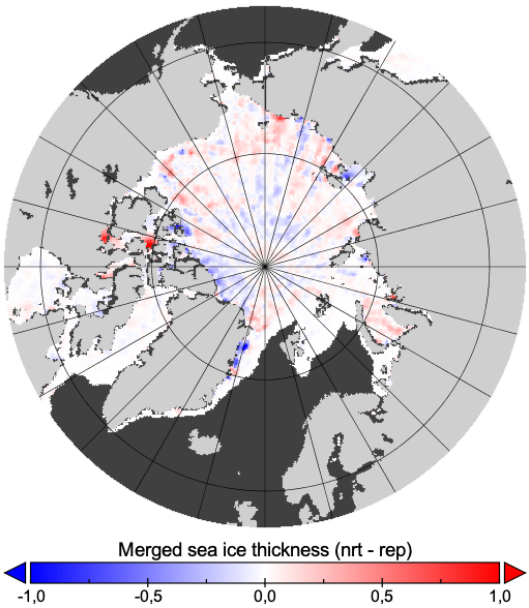

Figure 2: Thickness difference in meters between operational and reprocessed product for the week March 26, 2018 – April 01, 2018.

Differences between CS2SMOS v1.4-reprocessed and v2.0-reprocessed

Due to changes caused by the CryoSat-2 sea ice thickness retrieval version switch from v1.2 to v2.1, also thickness changes in the merged CS2SMOS product version v200 and v201 are espected. Figure 3 shows the differences for the week March 27, 2017 – April 02, 2017. Differences are in the same order for other weeks.

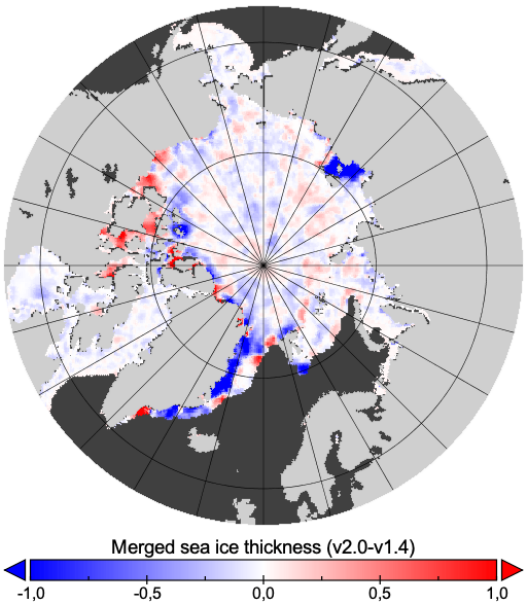

Figure 3: Thickness difference in meters between product v201 (r) and product v1.4 (r) for the week March 26, 2018 – April 01, 2018.

Product validation

For Validation, we use ULS ice draft data from moorings that have been deployed at four different sites in the Beaufort Sea within the BGEP project (Woods Hole Oceanographic Institution (WHOI), Krishfield and Proshutinsky, 2006). Data are sampled at 2s intervals. Ice draft is converted to ice thickness by multiplying the draft by 1.1 (Rothrock et al., 2008). Table 1 provides the position of the moorings in the Beaufort Sea and information about the ULS record periods. They cover the SMOS and CryoSat-2 periods (A, B, D). For the comparison of the merged CS2SMOS ice thickness and the ULS ice thickness measurements, open water sections within the ULS data set have been removed. Afterwards, the filtered data were averaged over 24 h to obtain daily mean effective ice thickness for each ULS (A, B, D). In the last step, daily retrievals are averaged weekly on a 25 km EASE2 grid to cover the same period as the weekly CS2SMOS products. Since the positions of the moorings are steady, one pixel for each ULS (A, B, D) is retrieved per week and is then compared with the gridded weekly mean of the CS2SMOS ice thickness.
Figure 4 shows the positions of the moorings and the corresponding differences to the SIT CDR. Mean differences (MD) are calculated by subtracting ULS ice thickness from satellite ice thickness. Considering the entire ULS data set as the reference, the MD is -0.1 m, while the root mean square deviation is 0.36 m.

Table 1: Mooring sites with ULS measurements used in this document.

Mooring Site	ULS record periods	Location
A	08/2003 – 10/2016	150.0°W 75.0°N
B	08/2003 – 09/2005 09/2006 – 09/2009 10/2010 – 10/2016	150.0°W 80.0°N
D	09/2006 – 10/2016	140.0°W 74.0°N

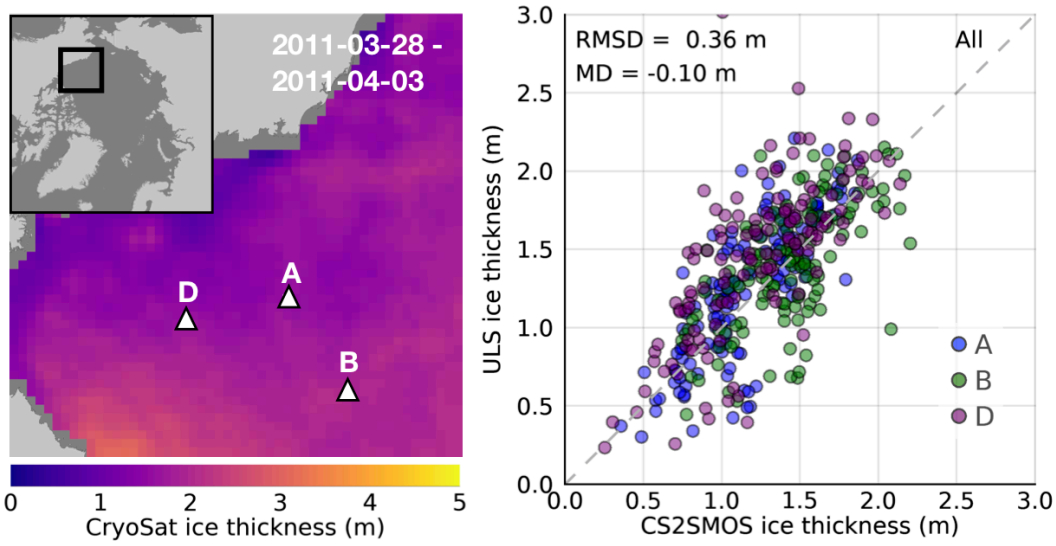

Figure 4: Overview of the ULS locations (left panel), and scatter plot between ULS and CS2SMOS ice thickness over the period Nov 2010 – Oct 2016. The RMSD represents the root mean square deviation. The bias represents the mean difference between CS2SMOS and ULS ice thickness.

4. Caveats

Major caveats are listed below:

Issue	Product Version	Status
Underestimation of SMOS ice thickness when ice concentration is lower than 100%	200/201	open
Fundamental calibration of CryoSat- 2 range retracking algorithm required	200/201	open
New data mask in OSI-401 v3.0 introduced in May 2016 leads to inconsistency to former CS2SMOS retrievals with regard to the ice-covered area, especially in coastal regions. This affects calculations of sea ice volume. Sea-ice thickness, however, is not affected. We account for this switch by a switch from CS2SMOS version v200 to v201 in May 2016	200/201	open

5. Future algorithm evolution

The aim is to include CryoSat-2 Baffin Bay data into the data merging. Currently these data are discarded, because the CryoSat-2 thickness retrieval (v1.2) uses the Warren 1999 snow climatology, which is not applicable in the Baffin Bay. The CryoSat-2 thickness retrieval (v2.1) uses an updated climatology, which is valid in the Baffin Bay. Therefore, these data will be included in the next major release of the CS2SMOS product.
We also want to investigate the capability of expand the processing to the Southern hemisphere.

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